Numerical Analysis of Microwave Detection of Breast Tumours using Synthetic Focussing Techniques

R.Nilavalan, J.Leendertz, I.J.Craddock, A. Preece, and R.Benjamin

Overview

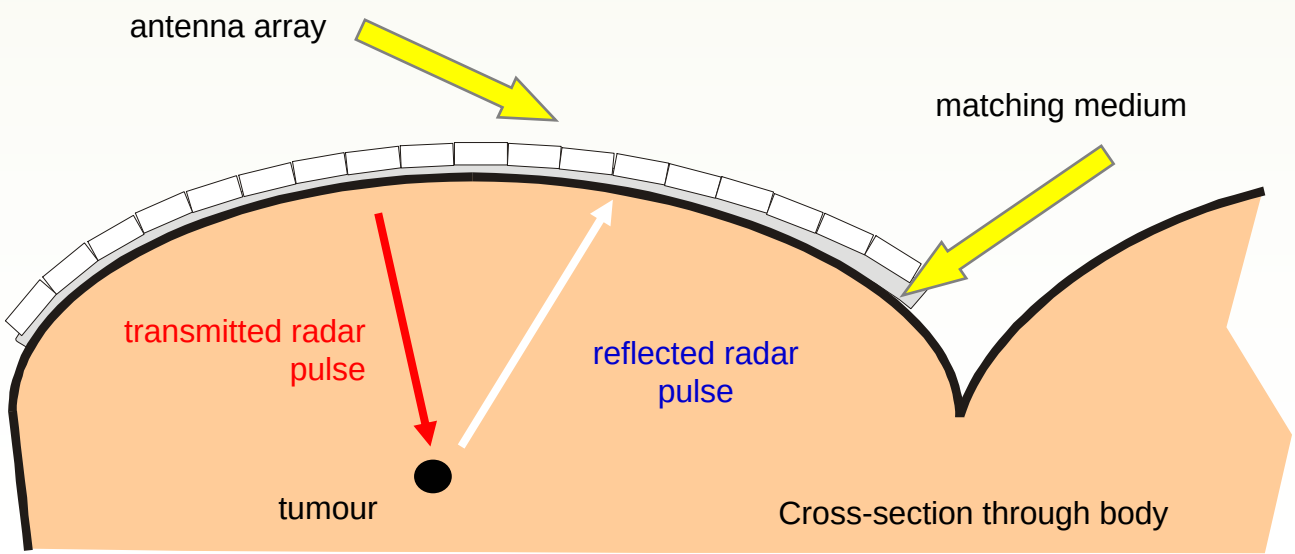
- Breast cancer facts
- The microwave imaging technique used at Bristol.
- Validation using FDTD, and skin clutter mitigation.
- Practical measurements (produced since paper submission)
- Future work
- Conclusions

Breast Cancer Facts

- Breast cancer is one of the most common cancers in women
- A woman will be diagnosed with breast cancer every 3 minutes in US alone.
- Breast Imaging Techniques
  - X-ray Mammography
    - Relatively high false negative rate: 4%- 34%
    - High false positive rate : 70%
    - Poor contrast resolution
    - Ionising
    - Uncomfortable
  - Ultrasound Methods
    - Small tumours have been detected
    - Poor spatial resolution
  - Contrast Enhanced MRI
    - Too costly for mass screening purposes

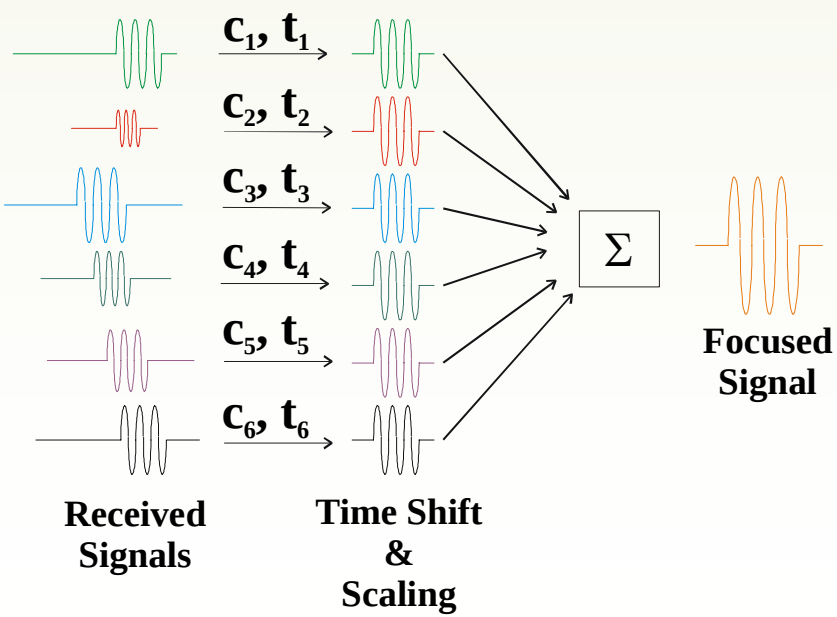
Microwave Detection

- Clutter is a major problem.
- Especially skin reflection (also mutuals, tissue inhomogeneity, chest wall).
- A radar technique investigated in the field of Landmine Detection at Bristol gives good clutter rejection by combining **all possible** TX/RX **pairs in an antenna array**.



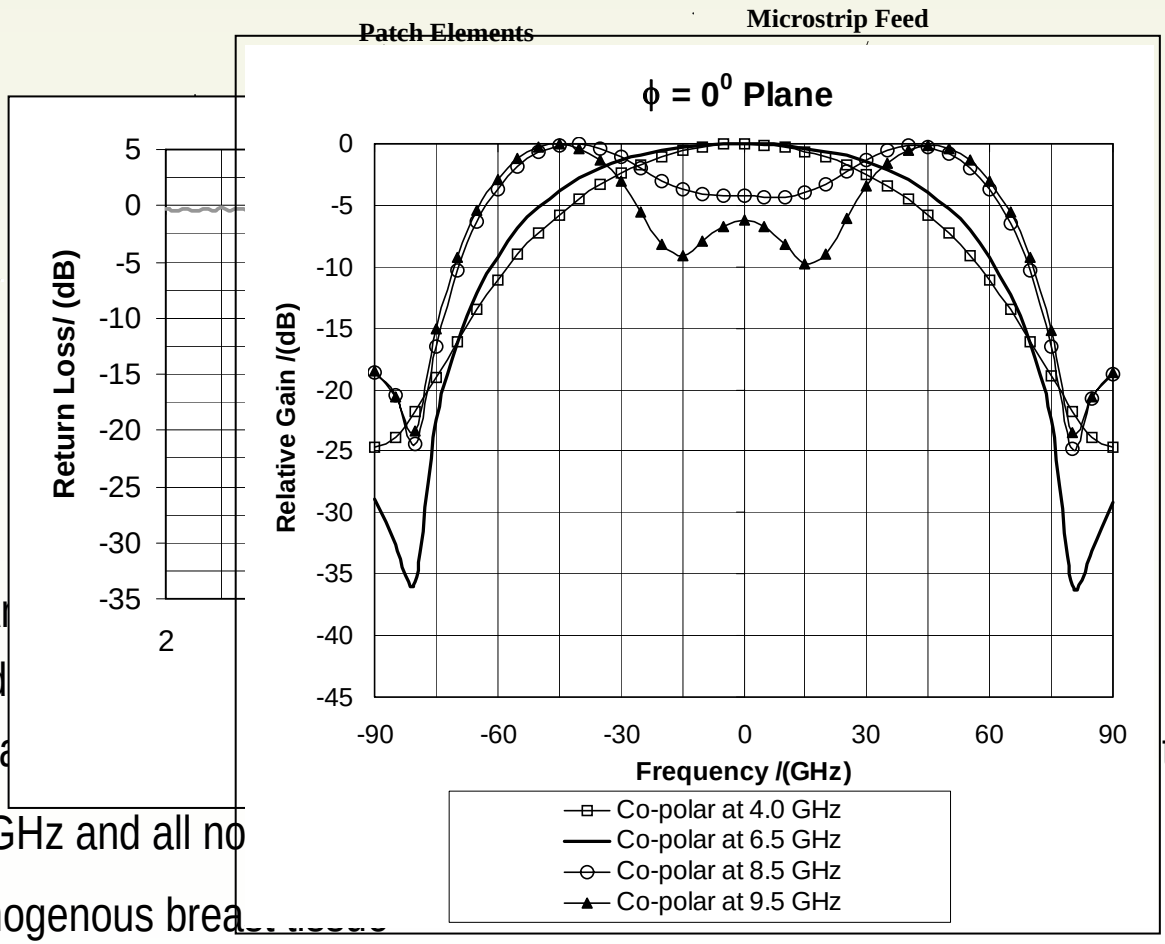
Microwave Imaging

- Real Aperture Synthetically Organised Radar
  - Number of paths is N(N-1)/2 (very large)



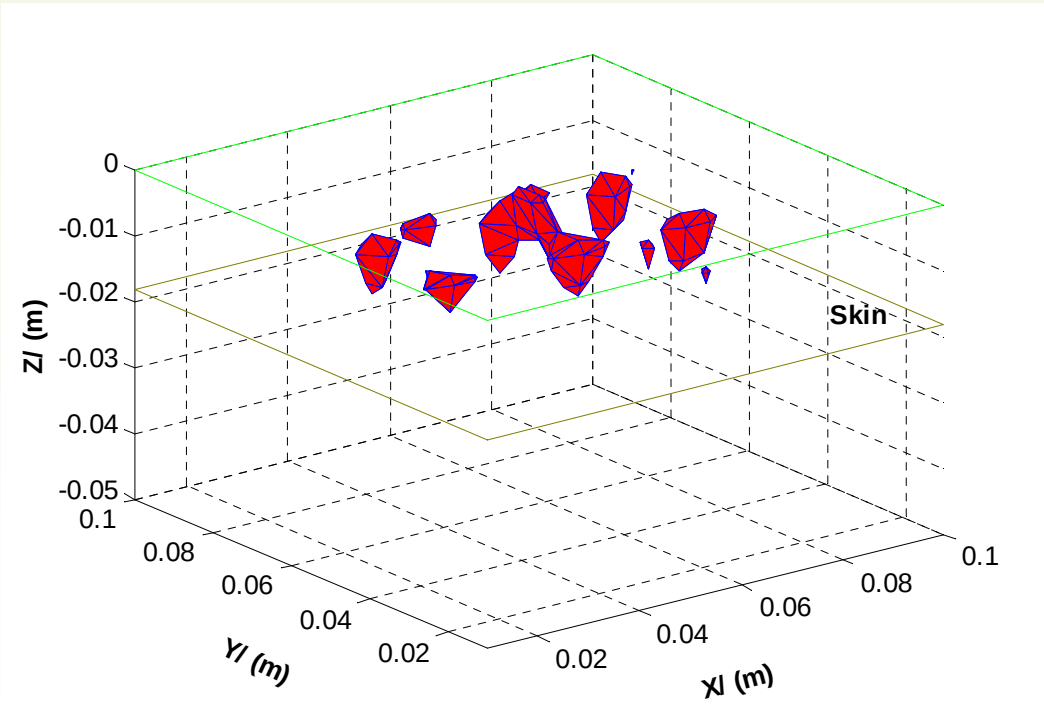
$$V = \int_0^{\tau} \left(\sum_{i=1}^{N} c_i U_i (t - t_i) \right)^2 dt$$

FDTD Model



- 16 A
- Yield
- The a two-cycle pulse at 6.5 GHz and all no
- Homogenous brea
  - Tumour $\varepsilon_r = 50 + j1.02$
  - Skin $\varepsilon_r = 40 + j5.86$

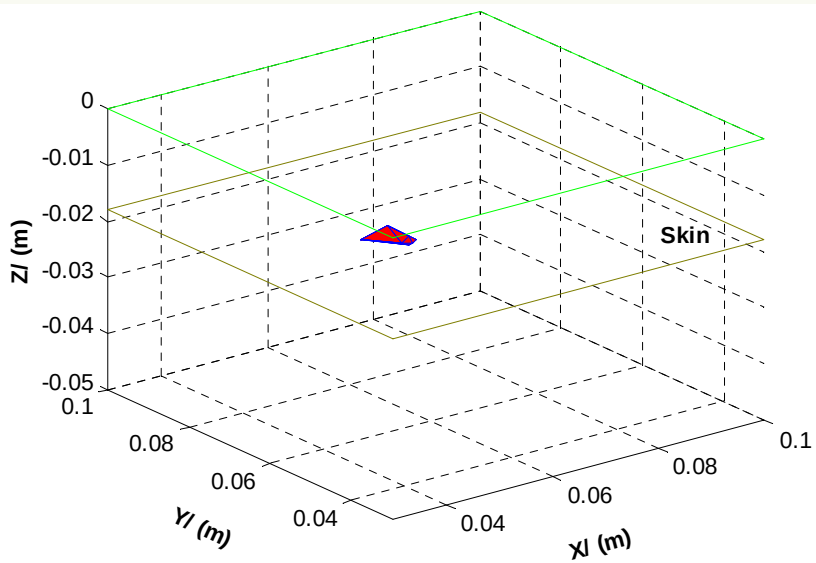
FDTD Model Results (1)

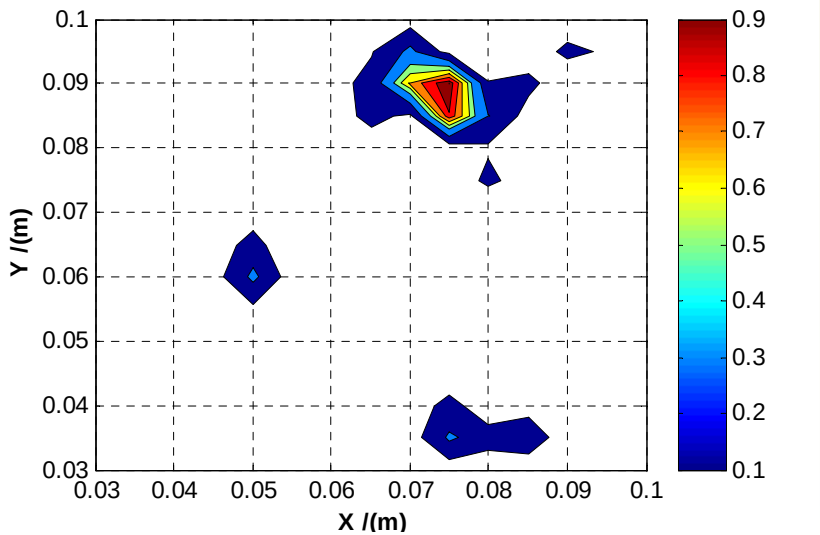


- Reflection from skin dominates the results.
- 2mm tumour is obscured.

FDTD Model Results (2)

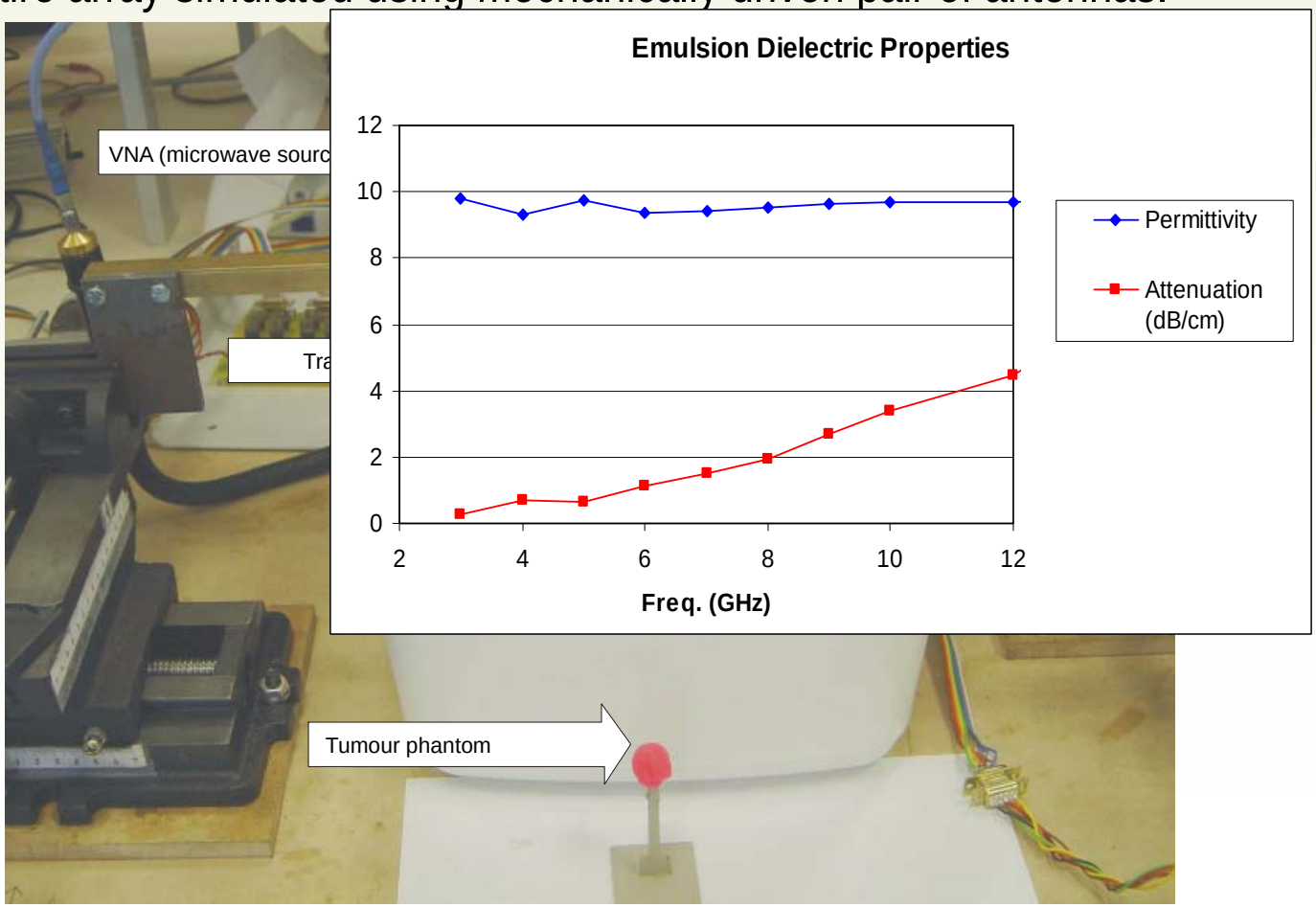
- If the array is offset slightly from the initial position, the reflection from skin stays largely the same, but the response from the tumour is displaced.
- On subtraction this gives a negative and positive image.
- This provides a simple mechanism for mitigating surface reflection:





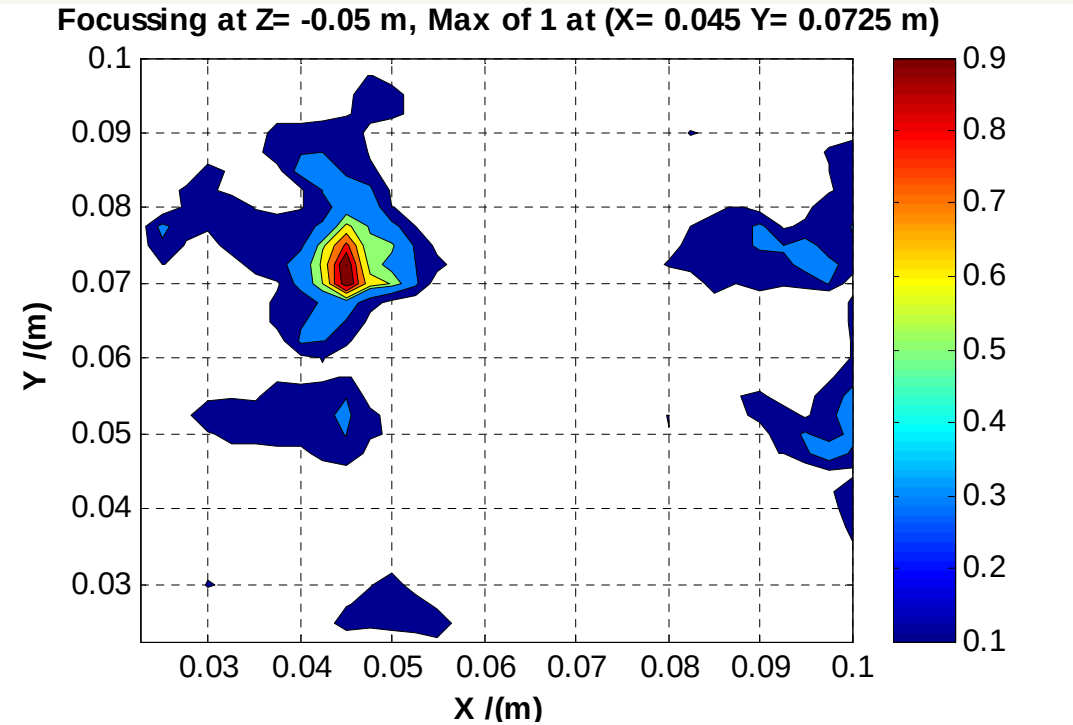
Practical Set-Up

- Entire array simulated using mechanically driven pair of antennas.



Practical Results

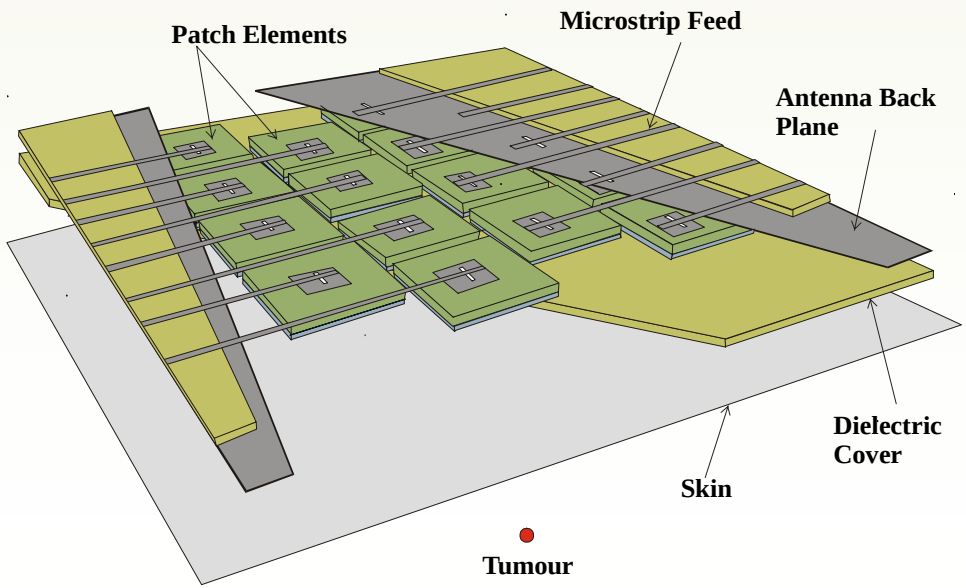
- Skin effect mitigated using the offset technique described here.



- 6mm tumour (position x =46mm, y = 69mm, z = -45mm).

Future Work

- Alternative skin clutter suppression techniques have been developed.
- The fully-populated antenna array (designed using FDTD) arrives on Thursday.
- RF switching and switch-driving system is under construction.



Conclusions

- Breast cancer detection using microwaves would be a very attractive, freely repeatable, and low-cost alternative, or adjunct, to Mammography.
- Detailed, realistic, FDTD models have been invaluable in designing antenna elements and validating the focussing and clutter-rejection techniques.
- A simple array-offset scheme gives good reduction in skin clutter and is practically feasible.
- Other skin clutter rejection techniques arise from the identification of similar paths with the array.
- Practical work with realistic phantoms has yielded results in line with expectations from FDTD.
- A fully-populated array is in the final stages of construction.